CLAIMS

What is claimed is:

1. An accelerometer of an implantable medical device having a first terminal corresponding to a first plate of a first capacitor, a second terminal corresponding to a second plate of said first capacitor and a first plate of a second capacitor, and a third terminal corresponding to a second plate of said second capacitor, the accelerometer comprising:

a first substrate coupled to the first terminal of the accelerometer, said first substrate being said first plate of the first capacitor;

a second substrate bonded to said first substrate, said second substrate comprising:

a moveable mass coupled to the second terminal of the accelerometer, said moveable mass being the second plate of the first capacitor and a first plate of the second capacitor;

at least one spring coupled to said moveable mass and said second substrate; and

a third substrate bonded to said second substrate, said third substrate coupled to the third terminal of the accelerometer, said third substrate being the second plate of the second capacitor, wherein the moveable mass is prevented from moving in a direction that inelastically flexes the at least one spring.

2. The accelerometer as recited in claim 1 wherein at least one over travel stop is formed on said moveable mass.

3. The accelerometer as recited in claim 1 wherein at least one over travel stop is formed on said second substrate.

4. The accelerometer as recited in claim 1 wherein said first, second, and third substrates comprise silicon.

5. The accelerometer as recited in claim 4 wherein a crystal orientation of said silicon is <100> and wherein said silicon is n-type.

6. The accelerometer as recited in 5 wherein said first substrate and said second substrate are fusion bonded together with an oxide layer and wherein said second substrate and said third substrate are fusion bonded together with an oxide layer.

7. The accelerometer as recited in claim 1 wherein electrical contact regions corresponding to the first, second, and third terminals of the accelerometer are formed on an exposed surface of said third substrate.

8. The accelerometer as recited in claim 7 wherein solder bumps are formed on said electrical contact regions of the accelerometer on said exposed surface of said third substrate allowing flip chip mounting of the accelerometer.

9. The accelerometer as recited in claim 1 wherein a first electrical contact region is formed on a major surface of said third substrate and wherein said first electrical contact region is coupled to said first substrate through an electrical contact that couples through said second and third substrates.

10. The accelerometer as recited in claim 9 wherein a second electrical contact region is formed on said major surface of said third substrate, the second electrical contact region coupling to said moveable mass and wherein said second electrical contact region is coupled to said moveable mass through an electrical contact that couples through said third substrate.

11. The accelerometer as recited in claim 10 wherein a third electrical contact region is formed on said major surface of said third substrate, said third electrical contact region coupling to said third substrate.

12. The accelerometer as recited in claim 1 wherein said moveable mass is suspended by springs coupled to a single side of said moveable mass.

13. The accelerometer as recited in claim 1 wherein said moveable mass is suspended by springs coupled to more than one side of said moveable mass.

14. An implantable medical device comprising:

a substrate having interconnect for coupling to circuitry of the implantable medical device; and

at least one accelerometer flip chip mounted to the substrate wherein the at least one accelerometer includes a moveable mass coupled to the at least one accelerometer by at least one spring and wherein movement of the moveable mass is limited to prevent inelastic flexing of the spring.

15. The implantable medical device as recited in claim 14 wherein the circuitry of the implantable medical device includes a pulse generator.

16. The implantable medical device as recited in claim 14 wherein the at least one accelerometer is a single axis accelerometer.

17. The implantable medical device as recited in claim 14 wherein the at least one accelerometer is a variable capacitance accelerometer.

18. The implantable medical device as recited in claim 17 wherein the at least one accelerometer comprises three substrates bonded together with the moveable mass being formed in a middle substrate, and wherein the implantable medical device further comprises at least one over travel stop to limit movement of the moveable mass.

19. A method of manufacturing a single axis accelerometer comprising the steps of:

providing a first semiconductor substrate;

forming a moveable mass in a second semiconductor substrate having a plurality of springs coupled from the moveable mass to the second substrate;

releasing the moveable mass using a dry etch such that the moveable mass is limited from moving in any direction that inelastically flexes the plurality of springs;

providing a third semiconductor substrate;

coupling the first semiconductor substrate to the second semiconductor substrate; and

coupling the third semiconductor substrate to the second semiconductor substrate.

20. The method of manufacturing a single axis accelerometer as recited in claim 19 further including a step of using n-type <100> silicon for the first, second, and third semiconductor substrate.

21. The method of manufacturing a single axis accelerometer as recited in claim 20 further including the steps of:

forming at least one p-well on a surface of the second semiconductor substrate;

forming an epitaxial layer overlying the surface of the second semiconductor substrate; and

using the at least one p-well as an etch stop in forming the moveable mass and the plurality of springs wherein the plurality of springs comprises material from the epitaxial layer.

22. The method of manufacturing a single axis accelerometer as recited in claim 21 further including the steps of:

forming a non-conductive layer on a surface of the first semiconductor substrate to prevent a short condition when the moveable mass contacts the first semiconductor substrate; and

forming a non-conductive layer on a surface of the third semiconductor substrate to prevent a short condition when the moveable mass contacts the third semiconductor substrate.

23. The method of manufacturing a single axis accelerometer as recited in claim 19 further including the steps of:

forming at least one over travel stop on the moveable mass; and

using a dry etch to etch a space between the at least one over travel stop and the second semiconductor substrate wherein spacing between the at least one over travel stop and the second semiconductor substrate limits movement of the moveable mass such that the plurality of springs do not inelastically flex.

24. The method of manufacturing a single axis accelerometer as recited in claim 19 further including the steps of:

forming at least one over travel stop on the second semiconductor substrate; and

using a dry etch to etch a space between the at least one over travel stop and the moveable mass wherein spacing between the at least one over travel stop and the second semiconductor substrate limits movement of the moveable mass such that the plurality of springs do not inelastically flex.

25. The method of manufacturing a single axis accelerometer as recited in claim 19 further including a step of forming the plurality of springs on single side of the moveable mass.

26. The method of manufacturing a single axis accelerometer as recited in claim 19 further including a step of forming the plurality of springs on more than one side of the moveable mass.

27. The method of manufacturing a single axis accelerometer as recited in claim 19 further including the steps of:

forming a first via through the third semiconductor substrate and the second semiconductor substrate to expose the first semiconductor substrate;

forming a first electrical contact region on a surface of the third semiconductor substrate that couples to the first substrate through the first via;

forming a second via through the third semiconductor substrate to expose the second semiconductor substrate;

forming a second electrical contact region on the surface of the third semiconductor substrate that couples to the second semiconductor substrate through the second via; and

forming a third electrical contact region on the surface of the third semiconductor substrate that couples to the third semiconductor substrate.

28. The method of manufacturing a single axis accelerometer as recited in claim 27 further including a step of solder bumping the first, second, and third electrical contact regions to allow coupling of the single axis accelerometer to another substrate.

29. The method of manufacturing a single axis accelerometer as recited in claim 19 wherein the step of coupling the first semiconductor substrate to the second semiconductor substrate further includes the steps of:

using oxide fusion bonding to couple a major surface of the first semiconductor substrate to a first major surface of the second semiconductor substrate wherein the major surface of the first

substrate is spaced a first predetermined distance from the moveable mass; and

using oxide fusion bonding to couple a major surface of the third semiconductor substrate to a second major surface of the second semiconductor substrate wherein the major surface of the third semiconductor substrate is a second predetermined distance from the moveable mass.